INSTRUCTION MANUAL

REGULATED DC POWER SUPPLY

PAD-L, TYPE I_2

Kikusui
INTERNATIONAL CORP.

INSTRUCTION MANUAL

REGULATED DC POWER SUPPLY

PAD-L, TYPE I_2

APPLICABLE MODELS

PAD 8-20L

PAD 16-18L

PAD 35-10L

PAD 55-6L

PAD 70-5L

PAD 110-3L

PAD 160-2L

KIKUSUI ELECTRONICS CORPORATION

On Power Supply Source, it is requested to replace the related places in the instruction manual with the following items.

(Please apply the item of √ mark)

☑ Power Supply Voltage: to ~~2~~ 120 ...V AC

☐ Line Fuse: to .....A

☑ Power Cable: to 3-core cable (See Fig. 1 for the colors)

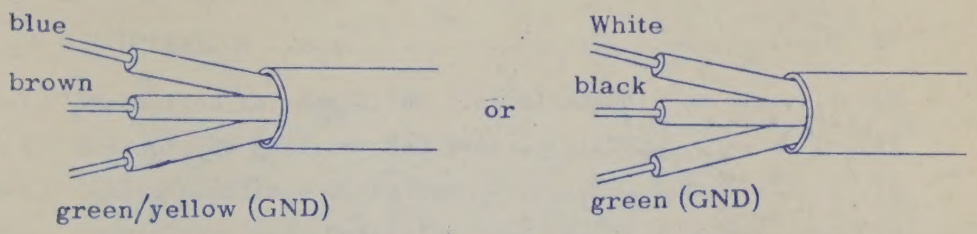

Fig. 1

Please be advised beforehand that the above matter may cause some alteration against explanation or circuit diagram in the instruction manual.

* AC Plug : In case of the Line Voltage 125V AC or more, AC Plug is in principle taken off and delivered, in view of the safety.

(AC Plug on 3-core cable is taken off in regardless of input voltages.)

Before using the instrument, it is requested to fix a suitable plug for the voltage used.

TABLE OF CONTENTS

PAGE

SECTION 1. GENERAL 1

1-1. Description 1

1-2. Specifications 3

* Current consumption Chart 7

* Mechanical outline drawing 9

SECTION 2. OPERATION 10

2-1. Precaution for Operation (Installation) 10

2-2. Explanation of Front and Rear 15

2-3. Constant-voltage Operation 18

2-4. Constant-current Operation 20

SECTION 3. PROTECTORS 21

3-1. Description 21

SECTION 4. APPLICATIONS 24

4-1. Remote Sensing 24

4-2. Output Voltage Control with an External Voltage or Resistance 25

4-3. On-off Control of Output 32

4-4. Output Current Control with an External Voltage or Resistance 34

4-5. One-control Parallel Operation 37

4-6. One-control Series Operation 39

4-7. Constant-current Discharge of Battery or Capacitor . 41

* Connections of rear terminals 43

* Block diagram 44

SECTION 5. MAINTENANCE 45

5-1. Inspection and Adjustment 45

5-2. Troubleshooting 49

SECTION 1. GENERAL

1-1. Description

The PAD-L Power Supply is an instrument with high operation reliability and excellent electrical performance.
It is a universal-purpose industrial power supply which can be used as a variable power source for research and development, or as a fixed power source for long-time aging test. Features of the PAD-L Power Supply can be summarized as follows:

1. Improved power factor at low output voltage:

   A choke input system is used for the rectifier filter circuit, thereby reducing the apparent input current and improving the power factor. This led to a smaller power transformer and consequently to a compact and light power supply.

2. Less waveform distortion caused to the AC input line:

   As the choke input system is used, the input current waveform is less distorted with harmonics, thereby reducing waveform distortion to the AC power line.

3. Excellent temperature coefficient:

   Very low temperature drift characteristics of 50 ppm/°C is attained by using premium-quality parts, improved circuits, and forced air cooling. Drift (time effect) also is very low.

4. Fast transient response:

   A wide-band error amplifier is used to ensure stable frequency - gain, phase characteristics and to provide a sufficient loop gain up to a high frequency. The output impedance

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of the instrument is low and the instrument rapidly responds to transiential load change.

5. Low ripple and noise voltages:

   Ripple and noise voltages are low, both in rms and peak values.

The output voltage is finely adjustable from 0 V to the rated voltage with a 10-turn potentiometer.

The power supply has a current/voltage limit switch to preset a current/voltage limit value. The set value of constant-voltage/constant-current operation can be checked when in operation.

The power supply has internal protection such as voltage detector, current detector and temperature detector circuits. An overvoltage protector (OVP), voltage adjustable from the front panel, also is incorporated as a standard feature. A high speed overvoltage protector (a thyristor crowbar protection circuit) is available as an option.

The power supply is housed in a casing for bench top use. It can be installed on a standard 19-inch (500-mm) rack.

The user is requested to read thoroughly this instruction manual before operating the power supply.

* It is highly recommended to use the thyristor crowbar high-speed overvoltage protector OVP (option) for a load whose allowable voltage range is very narrow and which could be damaged when a slight overvoltage is applied.

1-2. Specifications

Model	PAD 16-18L	PAD 35-10L	PAD 55-6L	PAD 70-5L	PAD 110-3L	PAD 160-2L	PAD 8-20L
Input							
Input AC line	120V ±10%, 50/60Hz, 1ϕ						
Power consumption (120V AC, rated load)	Approx. 710VA	Approx. 820VA	Approx. 670VA	Approx. 710VA	Approx. 720VA	Approx. 590VA	Approx. 440VA
Output							
Output voltage range (10 turns)	0-16V	0-35V	0-55V	0-70V	0-110V	0-160V	0-8V
Voltage resolution (theoretical value)	3mV	7mV	10mV	13mV	20mV	30mV	1.5mV
Output current range (1 turn)	0-18A	0-10A	0-6A	0-5A	0-3A	0-2A	0-20A
Current resolution (theoretical value)	64mA	35mA	21mA	18mA	11mA	7mA	70mA
Constant-voltage characteristics							
Regulation *1							
Source effect (line regulation) (For ±10% change of line voltage)	0.005% + 1mV						
Load effect (load regulation) (For 0 to 100% change of output current)	0.005% + 1mV						
Ripple and noise (5 Hz - 1 MHz) rms *2	500μV	500μV	500μV	500μV	500μV	1mV	500μV
Transient response (typical) *3	50μsec (5 - 100% change)						
Temperature coefficient (typical)	100 ppm/°C						
Remote control resistance and voltage	Approx. 0 - 10kΩ, 0 - 9V, 0 - -10V						

Model	PAD 16-18L	PAD 35-10L	PAD 55-6L	PAD 70-5L	PAD 110-3L	PAD 160-2L	PAD 8-20L
Constant-current characteristics							
Regulation							
Source effect (line regulation) (For ±10% change of line voltage)	1mA	1mA	1mA	1mA	1mA	1mA	1mA
Load effect (load regulation) (For 0 to 100% change of output voltage)	3mA	3mA	3mA	2mA	2mA	2mA	3mA
Ripple and noise (5 Hz - 1 MHz) rms *2	5mA	2mA	2mA	2mA	1mA	1mA	5mA
Remote control resistance and voltage approx. (kΩ)/(V)	1/0.54	1/0.5	1/0.6	1/1	1/1	1/1	1/0.6
Operating ambient temperature range	0 - 40°C (32 - 104°F)						
Operating ambient humidity range	10% - 90% RH						
Cooling method	Forced air cooling with fan						
Polarity of output voltage	Positive or negative grounded						
Isolation from ground	± 250 V						
Protections							
Operation	Control transistors cut off and rectifier circuit turned off						
Trip temperature of thermal protector	100°C(212°F) at cooling package, 130°C(266°F) at power transformer						
Overvoltage protection (OVP)							
Voltage setting range *4	6-18V	6-38V	11-60V	15-80V	20-130V	30-180V	3-10V
Trigger pulse width *4	50msec	50msec	50msec	50msec	50msec	50msec	50msec
Input fuse rating (6.4 mm dia. × 32 mm max.)							
120V AC source	10A	10A	10A	10A	10A	10A	7A
Output fuse rating							
(6.4 mm dia. × 32 mm max.)	20A	10A	6A	5A	3A	2A	20A

Model	PAD 16-18L	PAD 35-10L	PAD 55-6L	PAD 70-5L	PAD 110-3L	PAD 160-2L	PAD 8-20L
Meters							
Voltmeter, Class 2.5	16V DC	35V DC	55V DC	70V DC	110V DC	160V DC	8V DC
Ammeter, Class 2.5	22A DC	12A DC	6A DC	5A DC	3A DC	2.2A DC	22A DC
Constant-voltage mode indication	CV: With green LED						
Constant-current mode indication	CC: With red LED						
Insulation resistances							
Between chassis and line	500V DC, 30MΩ or over						
Between chassis and output terminal	500V DC, 20MΩ or over						
Dimensions *5							
	210W × 140H × 310D mm						
Maximum dimensions	228W × 155H × 353D mm (PAD8-20L, 16-18L is 363 D mm.)						
Weight	Approx. 16 kg	Approx. 15 kg	Approx. 15 kg	Approx. 15 kg	Approx. 15 kg	Approx. 15 kg	Approx. 13 kg
Accessories (in carton)							
Instruction manual	1 copy						
Input line fuse (spare)							
For 120 V	10A, 1 ea.						7A 1 ea.
Input cord	Approx. 2.5 m, vinyl-covered wires, nominal core cross section 1.25 mm^2						
Others	Guard cap 1 set						

Notes: *1. Measured using the sensing terminals.

*2. Measured with the positive or negative output terminal grounded.

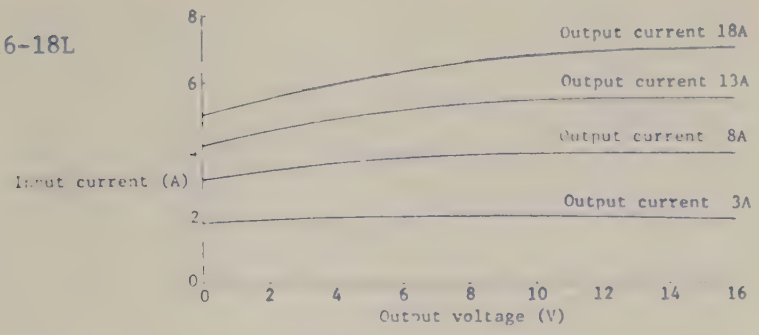
*3. Recavery time within 0.05% + 10mV of the output voltage.

*4. Typical value

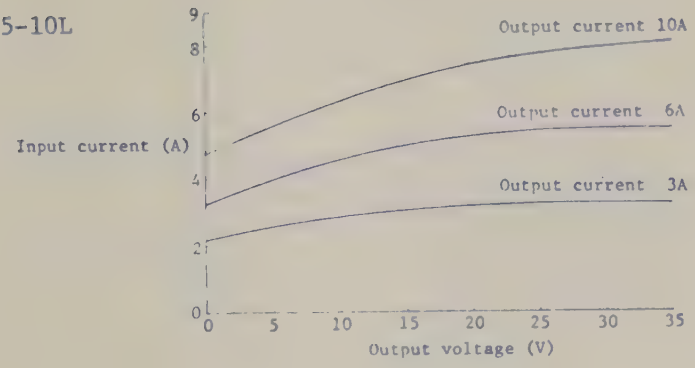
*5. With rack mount brackets (option), can be mounted on a standard 19-inch or 500-mm rack.

Current Consumption Chart 100V AC, 50Hz/60Hz

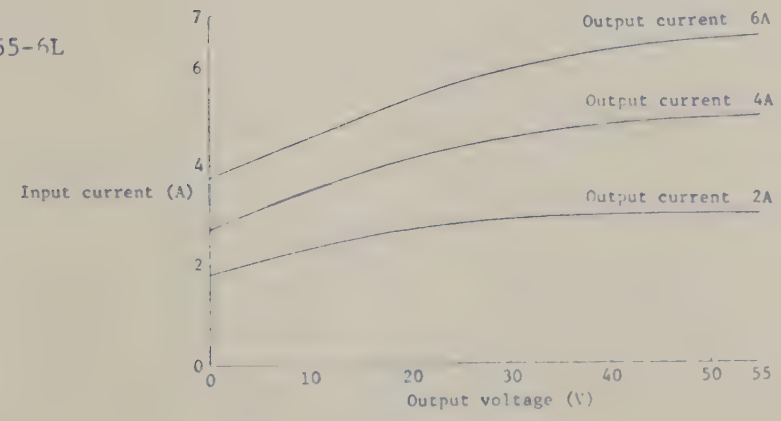
PAD 16-18L



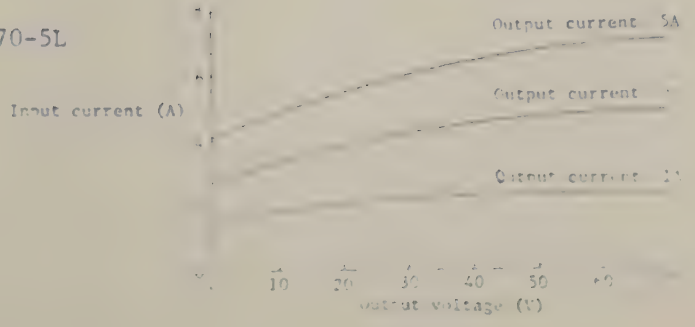
PAD 35-10L



PAD 55-6L

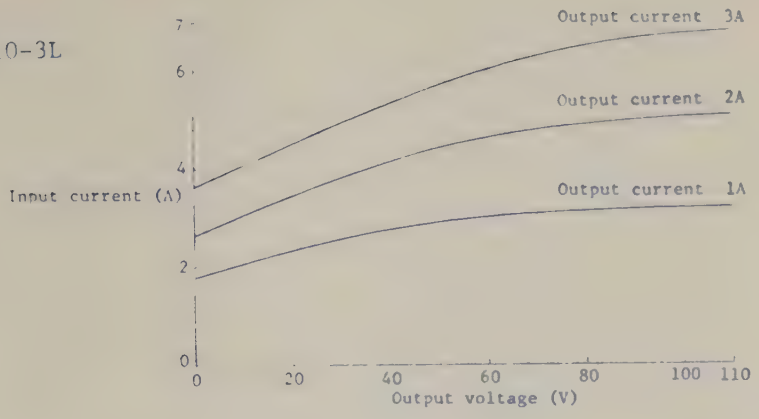


PAD 70-5L

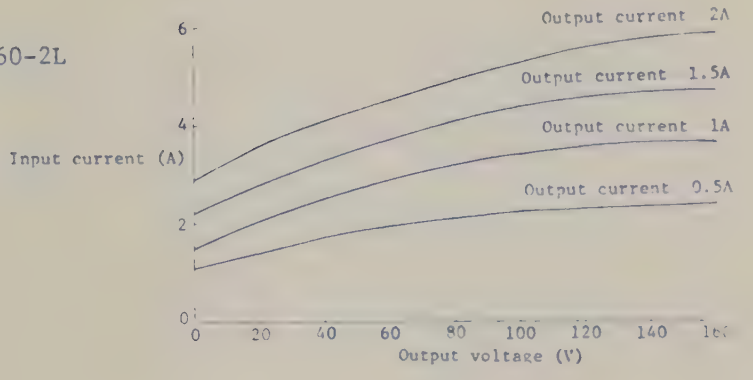


Current Consumption Chart 100V AC, 50Hz/60Hz

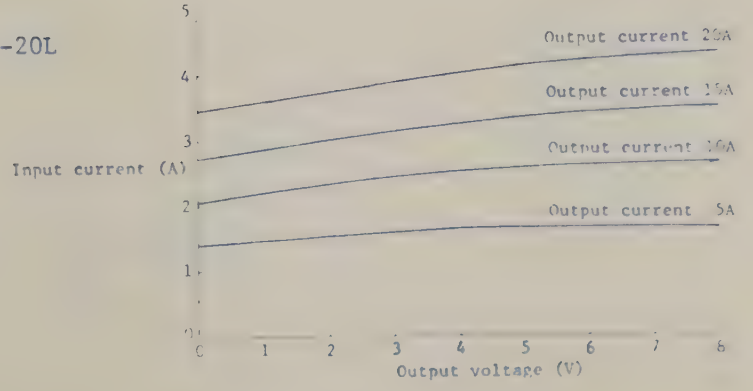
PAD 110-3L



PAD 160-2L



PAD 8-20L



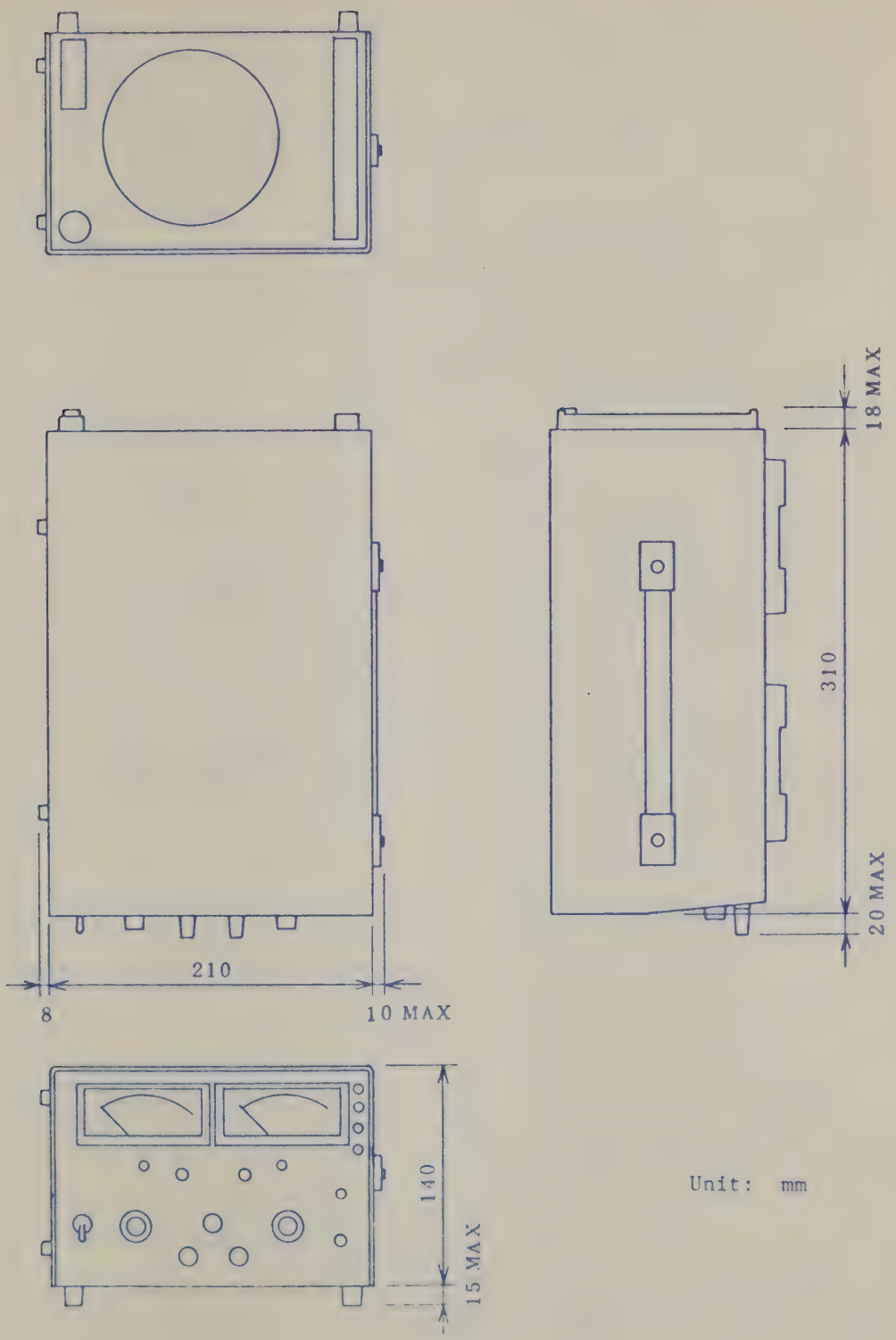


Figure 1-1. Mechanical Outline Drawing

SECTION 2. OPERATION METHOD

2-1. Precaution for Operation (Installation)

1. Input power

   - o The input line voltage range is 108 - 132 V, 48 - 62 Hz single-phase AC.
   - o The input power fuse rating is 10 A (7 A for PAD8-20L only).
   - o For current consumption, see the current consumption charts.

2. Power cord

   - o A power cord (core wires 1.25 mm^2) accompanies the power supply.

3. Output

   - o Make sure that the jumpers of the terminal blocks on the rear panel are securely connected as shown in Figure 2-1.

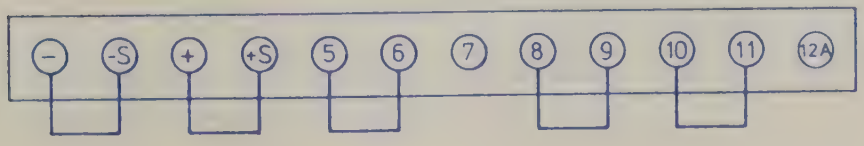


Figure 2-1

   - o Normally, connect either one of the output terminals to the GND terminal with the shorting bar.

4. Ambient temperature

   - o The ambient temperature range for the power supply to satisfy the specification performances is 0°C to 40°C (32°F to 104°F). The power supply should be used within this

range. If it is operated at a high ambient temperature, the internal temperature detector circuit trips and the input power switch is turned off. When this has happened, cool the power supply and then turn on the power again. There are exponential relationships between ambient temperature and semiconductor life, electrolytic capacitor life and transformer insulation life. Note that components are rapidly deteriorated at high temperatures. It is important not to operate the power supply at an abnormally high ambient temperature also from the viewpoint of its life.

- o If the power supply is used at a temperature lower than -10°C (14°F), its operation may become unstable. If the power supply is to be used at low temperatures, specify so when ordering.

5. Place for use

- o Pay attention so that the ventilation ports (top and bottom) and the fan air outlet are not blocked.
- o Hot air comes out of the fan air outlet. Do not place near the outlet any object which is not heat resistant.
- o Do not use the power supply in a highly humid or dusty place as such can cause failures.
- o Select a place where is reasonably free from vibration.
- o Do not place a high sensitivity instrument on or near the power supply, which produces a strong electric and magnetic fields.

6. Note for carrying.

- o The center of gravity of the power supply is at a leftward position. The instrument weighs approximately 15 kg (33 lbs). Be careful when raising the power supply without using the handles.

7. Note for battery charging

o Battery charging may be done by setting the charged-up voltage of the battery with the constant-current setting knob and the charging current with the constant-current knob. When this setting is done, charging automatically stops when the battery is charged up.

8. Note for load

Note that the output may become unstable depending on characteristics of loads as follows:

(a) Even when the meter reading (average value) is less than the present value, if the current has peaks which exceed the preset value, the operation is driven into the constant-current domain for short periods and therefore the output voltage falls. Observing carefully, it can be seen that the constant-current indicator lamp becomes dim.

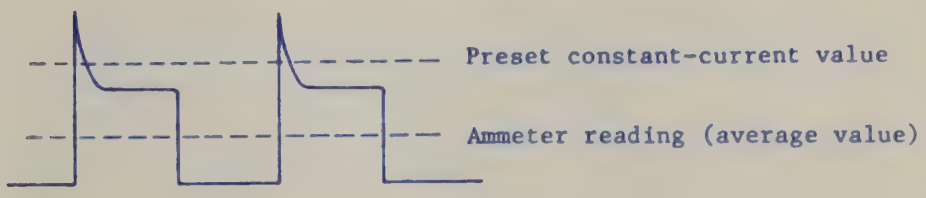


Figure 2-2. Load current with peaks

In this case, raise the preset value or increase the current rating.

(b) When a regenerative load (such as inverter, converter, or transformer) is connected to this power supply, as it cannot absorb the reverse current fed from the load, the output voltage increases and becomes unstable. In such a case, connect a bypass resistor (R) in parallel with the load and feed in this resistor a current larger than the maximum reverse current.

$$R\ [\Omega] \leq \frac{E_O\ [V]}{I_{RP}\ [A]}$$

where, E_O: Output voltage

I_{RP}: Maximum reverse current

9. Note for a guard cap

When a guard cap (accessory) used, the potentiometer is fixed or semi-fixed as shown under.

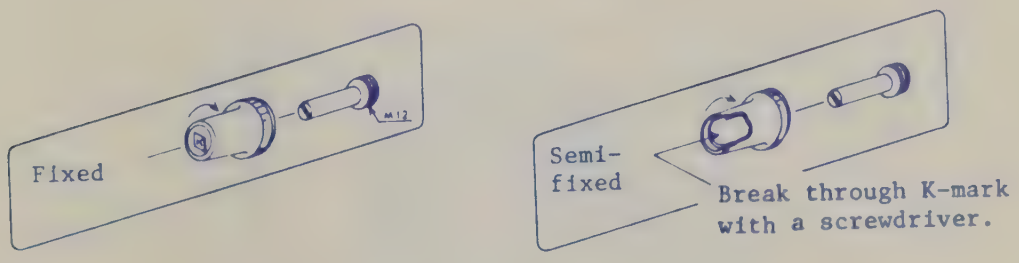


Figure 2-3

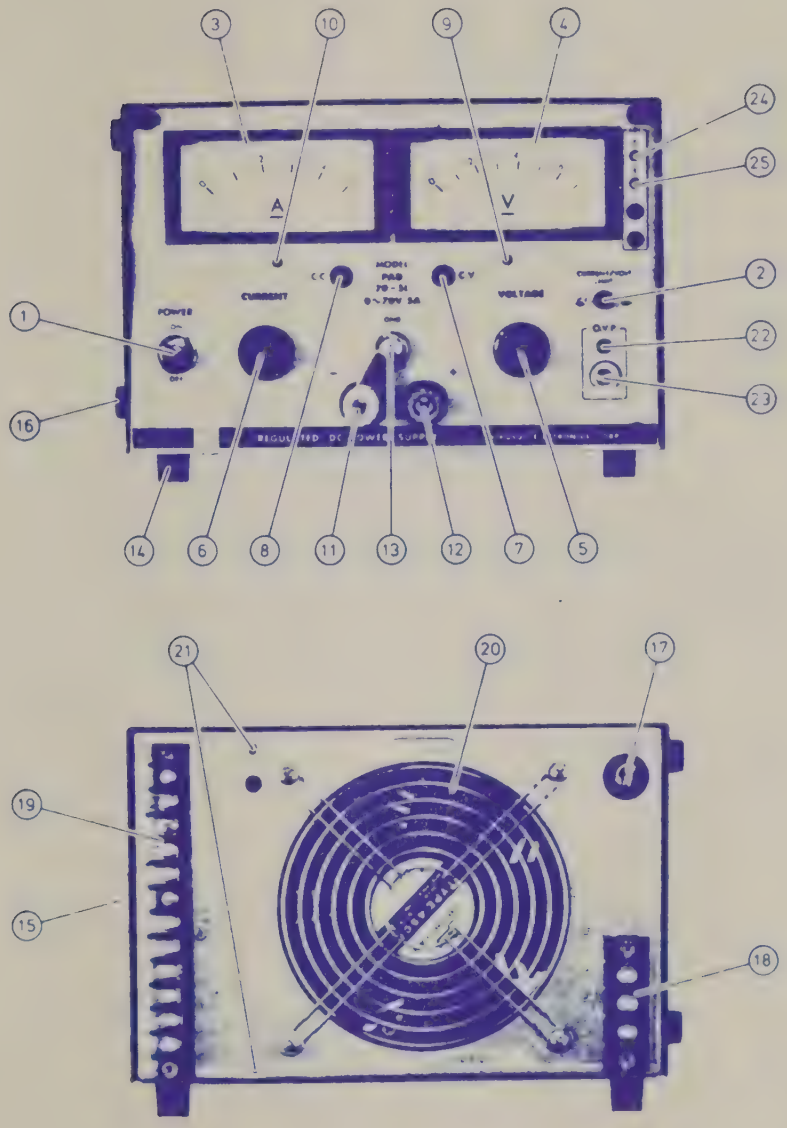


Figure 2-4. Front panel and rear panel

2-2. Explanation of Front and Rear

Panel items and descriptions

1. POWER switch:

   Serves as AC power switch. When thrown to the upper position, the input power is turned on and C.V or C.C lamp lights.

   Note: The input power cannot be turned on immediately after it has been turned off by the OVP function or other cause. Wait about five seconds and then turn on the input power.

2. CURRENT/VOLTAGE LIMIT switch:

   Push to set crossover point of C.V/C.C. The ammeter indicates the preset constant-current value and the voltmeter indicates the preset constant-voltage value.

3. Ammeter:

   Monitors output current. JIS Class 2.5

4. Voltmeter:

   Monitors output voltage. JIS Class 2.5

5. Voltage setting knob:

   Adjusts output voltage for constant-voltage operation. 10-turn potentiometer (See Figure 2-3.)

6. Current setting knob:

   Adjusts output current for constant-current operation. 1-turn potentiometer (See Figure 2-3.)

7. C.V. (constant-voltage operation indicator lamp):

   Energizes in constant-voltage mode. Green LED

8. C.C. (constant-current operation indicator lamp):

   Energizes in constant-current mode. Red LED

9. Voltmeter zero adjustment:

   For zero-volt indication adjustment of the voltmeter.

10. Ammeter zero adjustment:

    For zero-ampere indication adjustment of the ammeter.

11. Output terminal (- terminal):

    White binding post

12. Output terminal (+ terminal):

    Red binding post

13. GND terminal

14. Rubber stud

15. Carrying handle:

    For carrying the instrument.

16. Rubber stud:

    As a shock absorber when carrying the instrument by its handle.

17. Line fuse holder:

Houses a fuse (120 V AC, 10 A) for the AC input power line. (7 A for PAD8-20L)

18. Input terminal block:

Terminals for the input AC line power. To be connected with the input power cord (1.25 mm^2) supplied.

19. Terminal block:

Terminals for -, -S, +, +S, remote control, and one-control parallel operation.
(See SECTION 4 "APPLICATIONS.")

20. Fan exhaust area:

Air exit of the cooling package. As hot air comes out of this outlet, do not obstruct. The outlet must be positioned 30 cm or over from wall.

21. OVP mounting-holes:

For mounting the high speed overvoltage protector (option).

22. OVP indicator lamp:

Turns on when the overvoltage protector or the temperature detector has tripped.

23. Over Voltage Protector (OVP):

Setting procedure for OVP

(1) Turn the OVP resistor to the extremely clockwise position with a screwdriver.

(2) Set the output voltage at the required OVP operation point.

(3) Turn gradually the OVP resistor counterclockwise to the point where the OVP lamp turns on.

(4) Turn off the power switch to lower the output voltage. Then, turn on the power switch and ensure the operating point of the OVP function. Allow five seconds or more resetting time before turning on the power switch again.

24. Voltmeter calibration :

For voltmeter calibration. (See Section 5-1-3.)

25. Ammeter calibration :

For ammeter calibration. (See Section 5-1-4.)

2-3. Constant-voltage Operation

Method I

(1) Check first that the AC line voltage is 120V ±10% AC. Then, connect the input power cord.

(2) Turn on the input power switch. The indicator lamp will light indicating that the instrument power is on.

(3) Keeping depressed the current/voltage limit switch, set the output current at the required value with the current setting knob. By this procedure, setting of the output current is complete. Once this setting is done, no output current larger than the set value flows even when the load is rapidly changed. (The load is protected by automatically changing the instrument operation from the constant-voltage mode to the constant-current mode. This function is called "crossover".

(4) Set the output voltage at the required value with the VOLTAGE setting knob.

(5) Turn off the power switch, connect the power, and then turn on the power switch.

Note: When the load resistance is unpredictable or it is predicted to vary largely or when it has a large inductance and application of a rapidly changing voltage is undesirable, use such method that the power switch is turned on while keeping the set voltage at zero and then the voltage is gradually raised or that, keeping the voltage at the set value, the power switch is turned on while keeping the current setting knob at the extremely counterclockwise position and then the current is increased.

This instrument does not produce overshoots when its power is turned on or off.

This instrument is incorporated with a voltage limiting feature. This feature can be effectively utilized in the following type of operation.

Method II

(1) Connect the load to the instrument.

(2) Turn the constant-current knob to the extremely counterclockwise position. Turn on the power switch.

(3) Keeping depressed the current/voltage limit switch, set the voltage at the required value with the constant voltage knob.

(4) Turn clockwise the constant-current knob to the point where the constant-voltage indicator lamp (green) turns on.

2-4. Constant-current Operation

(1) Make sure that the AC line voltage is 120V ±10%. Then, connect the input power.

(2) Turn on the input power switch. The C.V. or C.C. lamp will turn on indicating that the power supply is in the operating state.

(3) Keeping depressed the current/voltage limit switch, set the current at the required value with the constant-current knob and, at the same time, set the voltage limit value with the constant-voltage knob. Once this setting is done, the load is protected against overvoltage.

(4) Turn off the input power switch. Connect the load to the output terminals of the power supply and, then, turn on the input power switch.

Note: If the load has a large inductance and it is undesirable to apply a rapidly changing current, set the current setting knob in the extremely counterclockwise position, turn on the power switch and then gradually increase the current.

* In order to ensure adjustment down to 0 V, a negative voltage of approximately -0.6 V is produced and a current of up to approximately 10 mA may flow when the constant-voltage knob or the constant-current knob is turned to the extremely counterclockwise position. Pay attention to this fact when the load is of such nature that the voltage of this low level matters. (Of the PAD8-20L and PAD16-18L, the negative output voltage is suppressed to a value smaller than -0.1 V.)

SECTION 3. PROTECTORS

3-1. Description

Regulated DC power supplies are used, as their name indicates, to supply regulated DC powers to various types of loads. Demands for regulated DC power supplies have rapidly increased in recent years. As is the case for other types of electronic equipment, these instruments are required to include features of high accuracy, fast response, high reliability, high efficiency, high power factor, compactness, light weight, and economical price. Various types of power supplies are available on the market today. When selecting regulated DC power supplies, in addition to satisfying the required performances, special attention must be paid to some particular requirements which are slightly different from those required by other types of electronic equipment which handle electronic signals.

The above difference comes from the fact that regulated DC power supplies handle "powers." Malfunctioning or erroneous operation of the power supply leads to shut down of the overall system, damage to the power supply equipment and precious load equipment, or to a fire in an extreme case. As the power supply provides the base for the entire electric and electronic circuits of the system to which it supplies the power, its reliability is very important. Protective features, which prevent serious damage when the power supply should fail, are important factors to be taken into consideration when selecting a power supply.

The PAD-L Regulated Power Supplies have been designed fully taking the above matters into consideration, as instruments of vary high reliability. They employ premium quality components, with sufficient derating. They are incorporated with protective circuits which lead them to "the safer side" should they fail. Individual protective circuits are explained in the following:

(1) Overvoltage protector:

A limiting voltage can be set from the instrument front panel. If the output voltage exceeds the preset voltage, the control transistor is cut off, the rectifier circuit is shut down and the OVP lamp turns on. The operation time is approximately 50 msec.

(2) Voltage detection circuit:

When the rated voltage of the electrolytic filter capacitor is exceeded due to such erroneous operation as disconnected jumper of the terminal block on the rear panel or due to a failure of the rectifier circuit, the rectifier circuit is instantaneously shut down.

(3) Temperature detection circuit:

Detects temperature of the cooling package (semiconductor cooling unit). When temperature of the cooling fins have become higher than approximately 100°C (212°F) due to ambient temperature rise or other reason, the control transistor is cut off and the rectifier circuit is shut down, and the OVP lamp turns on.

(4) High-speed overvoltage protector (option):

When the output voltage has exceeded the preset voltage due to erroneous operation or an external pulse voltage, the thyristor circuit connected between the output terminals instantaneously conducts to short-circuit the output and, at the same time, the control transistor is cut off and the rectifier circuit is shut down, and the OVP lamp turns on. The operation time is selectable from a range of several microseconds to several hundred microseconds.

(5) Power fuse:

Limits the input current.

(6) Output fuse:

Limits the output current.

(7) Thermal fuse:

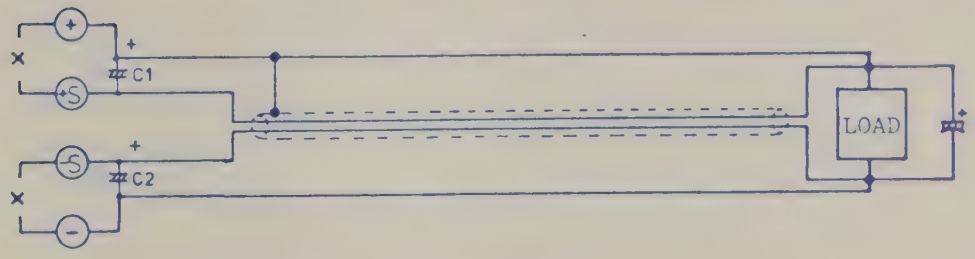
Mounted on the power transformer to guard it against overheat caused by layer-short of its secondary winding, etc. The thermal fuse cuts out the input power at approximately 130°C (266°F).

SECTION 4. APPLICATIONS

4-1. Remote Sensing

Voltage drop caused by the load connection wire resistance and contact resistance can be compensated for.

1. Turn off the input power switch.
2. Disconnect the jumper wires from between (+S) and (+) terminals and between (-S) and (-) terminals on the instrument rear panel.
3. Connect the (+S) and (-S) wires to the point where the output vontage drop is required to be compensated for. (Use a shielded cable in order to prevent induction of ripple noise voltage. Connect the external shielding wire to the (+) line of the output.)



C1, C2: Several hundreds μF, 16WV

Figure 4-1

Notes: 1. By this remote sensing feature, up to approximately 1.2 V of voltage drop can be compensated for. Note that, if the voltage drop is larger than 300 mV, the maximum rated voltage is reduced by the corresponding amount.

2. If the load connection cable is longer than 3 - 5 meters, phase shift caused by inductance and capacitance of the cable wires becomes noticeable and the circuit may oscillate. In such a case, connect an electrolytic capacitor of several hundred microfarads in parallel with the load as shown in Figure 4-1. (If oscillation cannot be eliminated still, disconnect the electrolytic capacitor at the back of the output terminals of this instrument or connect capacitors C1 and C2 as shown in Figure 4-1.

4-2. Output Voltage Control with an External Voltage or Resistance

o Control with an external resistance - I

The output voltage can be controlled in proportion to an external resistor.

1. Turn off the input power switch. (Be sure to turn off the input power switch before connecting or disconnecting wires of the rear terminals.)

2. Disconnect the jumper from between terminals (5) and (6).

3. Connect a 100-ohm potentiometer and another potentiometer (R1) between terminals (5) and (7).

4. Set R1 at zero and so adjust the 100-ohm potentiometer that the output voltage becomes zero.

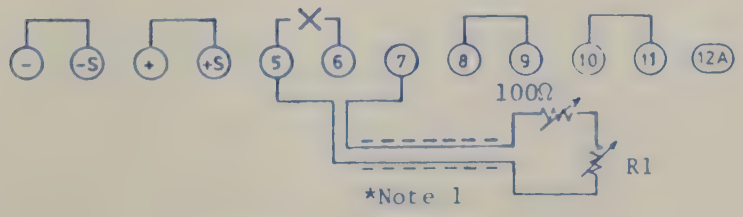


Figure 4-2

$$\text{Output voltage } Eo = \frac{Emax \cdot R1}{10} \text{ [V]}$$

where, $10 \geq R1$ [kΩ]

Emax: Rated output voltage [V]

For fine adjustment of Eo with respect to R1, use R4 shown in Figure 5-1.

*Note 1: Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" output terminal.

Application

- By using a fixed resistor and a potentiometer, the voltage can be varied by plus or minus several percent of the set voltage.
- Resolution of the output voltage depends on resistor R1. Therefore, required resolution can be obtained by using an appropriate value of potentiometer for R1.
- A programmed voltage can be obtained by varying the resistance with switch setting. (For this purpose, use switches of a closed circuit type or a continuous type which do not cause momentary open circuit.)

- Control with an external resistance - II

(This method is a fail-safe method free from overshoots even when resistors are switched.)

1. Turn off the input power switch.
2. Disconnect the jumper from between terminals (8) and (9).
3. Connect a resistor (potentiometer R1') between terminals (8) and (9).

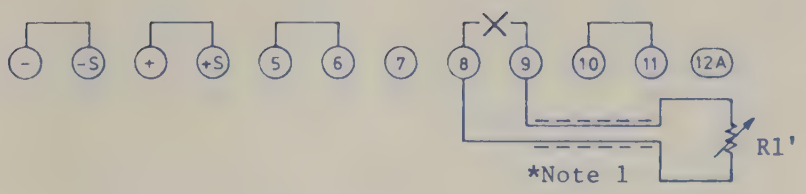


Figure 4-3

$$\text{Output voltage } Eo = \frac{9\ Emax}{9 + R1'} - \frac{RF}{10}$$

where, $0 \leq R1'\ [k\Omega] \leq \infty$ (infinitive)

Emax: Rated output voltage [V]

RF: Resistance of constant-voltage setting resistor [0 - 10 kΩ] (on the front panel)

For fine adjustment of Eo with respect to R1', use R4 shown in Figure 5-1.

*Note 1: Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" output terminal.

The output voltage (Eo) is inversely proportional to the resistance (R1') as shown below. Therefore, when the circuit has become open due to switching of resistors or a circuit failure and the resistance has become infinity, the output is reduced to zero.

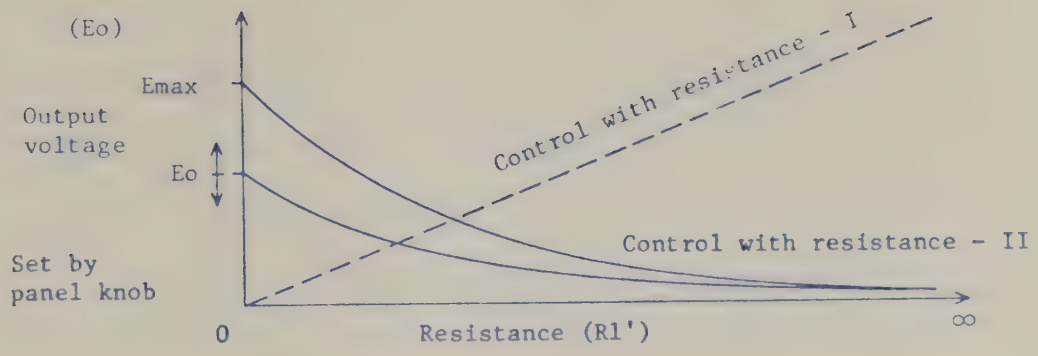


Figure 4-4

- o As shown in the above, output voltage can be varied also by varying the constant-voltage knob (R_F) on the front panel. When the knob on the front panel is required to be made ineffective, disconnect the shorting bar from between terminals (5) and (6) and connect a 10-kΩ or lower resistor of a good temperature coefficient between terminals (5) and (7) as is the case for "control with resistance - I.")

- o The primary objective of this mode of operation is to attain such a fail-safe feature that the output voltage drops when the output circuit is inadvertently made open. A disadvantage of this mode of operation is that an inhibitingly high resistor is required when programming for operation at low voltages. In general, a potentiometer of 200 kΩ or thereabout is suitable for Rl'. (When using a high resistor, pay attention to its temperature coefficient and noise property.)

- o Control with an external voltage

  * The instrument may be damaged if there is a wrong connection or if an abnormally large voltage is applied. Check for them once more before turning on the instrument power.

A. Control with a positive external voltage

1. Turn off the input power switch.

2. Disconnect the jumper from between terminals (5) and (6), connect a resistor R2 between (5) and (7).

3. Disconnect the jumper from between terminals (8) and (9).

4. Apply an external control voltage between terminals (+S) and (8). (Pay attention to the polarity.)

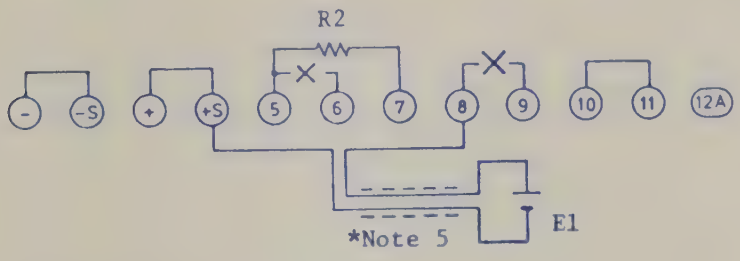


Figure 4-5

The resistance of resistor R2 [kΩ] is calculated with the following equation:

$$R2\ [k\Omega] = \frac{90\ Eo}{Emax\ E1} \quad \ldots\ldots\ldots\ldots\ (1)$$

where, Eo: Output voltage [V]
E1: External control voltage [V]
Emax: Maximum rated voltage [V]

For fine adjustment of Eo with respect to E1, use R4 shown in Figure 5-1.

Notes: 1. Make sure that the output voltage does not exceed the maximum rated voltage. ($Eo \leq Emax$)

2. Make sure that the external control voltage is within a range of 0 to 27 V. ($0 \leq E1 \leq 27$)

3. The resistance of R2 must not be greater than 100 kΩ. ($R2 \leq 100$ kΩ)

4. The input resistance of the circuit between terminals (+S) and (8) is approximately 9 kΩ.

5. Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" output terminal.

[Example]: To control the output voltage of PAD35-10L for a range of 0 - 30 [V] with an external signal of 0 - 30 [V].

Substituting terms of equation (1) as Eo = 30 [V], El = 10 [V] and Emax = 35 [V], the resistance is calculated as R2 ≒ 7.7 kΩ.

When the above method is used, the ratio between external control voltage and instrument output voltage can be varied. The input versus output characteristics are as shown in Figure 4-6 due to the offset voltage of the reference voltage circuit. The input offset voltage is approximately 50 mV.

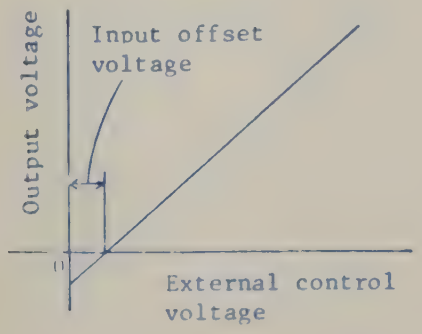


Figure 4-6

For a load for which the above input offset voltage matters, it is recommended to control the output voltage with a negative external voltage as explained in Method B which follows. With this method the offset voltage can be suppressed at less than 6 mV.

In either case, to reduce the offset voltage, a minor modification to the instrument is required. Contact Kikusui's agent in your area.

B. Control with a negative external voltage

1. Turn off the input power switch.
2. Disconnect the jumper from between terminals (5) and (6).
3. Short between terminals (+S) and (7).
4. Apply an external control voltage between terminals (+S) and (5), observing that the polarity is correct.

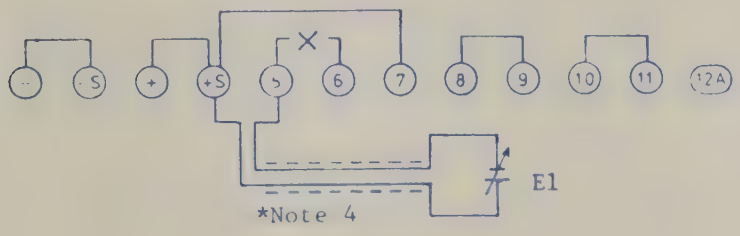


Figure 4-7

The output voltage can be expressed with the following equation:

$$Eo \fallingdotseq \frac{El \cdot Emax}{10} \quad [V]$$

where, Eo: Input voltage [V]
El: External control voltage [V]
Emax: Maximum rated voltage [V]

Notes: 1. Make sure that the output voltage does not exceed the maximum rated voltage. ($Eo \leq Emax$)

2. Make sure that the external control voltage does not exceed 11 V. ($El \leq 11$)

3. The input resistance of the circuit between terminals (+S) and (5) is approximately 100 kΩ. When in the voltage limit state, however, the input resistance becomes approximately 30 kΩ.

4. Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" terminal.

Caution: Before operating the instrument in the above mode, be sure to set the OVP circuit. Also be sure to pay attention to noise of the external control signal because this noise is amplified and superimposed on the output voltage of the instrument.

4-3. On-off Control of Output (with External Switch)

A. For voltage preset with voltage limit switch when output is off

1. Turn off the input power switch.

2. Connect an external switch between terminals (11) and (12A).

3. Turn on the input power switch. If the external switch is turned on, the output becomes almost zero. If it is turned off, the output power is delivered.

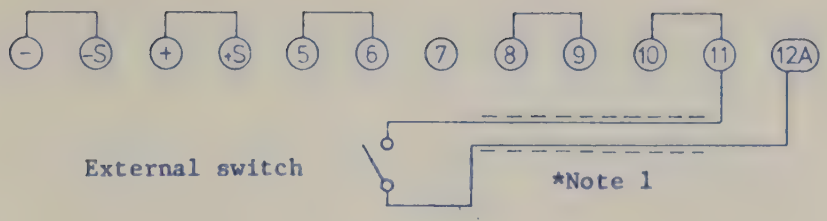


Figure 4-8

*Note 1: Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" output terminal.

Notes: When the output is off, the current limit switch cannot be used. However, as the voltage limit switch can be used, presetting of the output voltage can be done.

When the output is in the off state, the output voltage of less than 0.6 V in the reverse polarity may be produced and a current of several tens milliamperes may flow. If such voltage is not allowable, use method B explained in the next paragraph.

B. To make the output voltage accurately zero volts

1. Turn off the power switch.

2. Connect an external switch and a 100-ohm potentiometer between terminals (6) and (7).

3. Turn on the input power switch. Next, turn on the external switch.

4. Adjust the output voltage to zero volts with the potentiometer.

5. If the external switch is turned on, the output voltage becomes zero; if it is turned off, the output power is delivered.

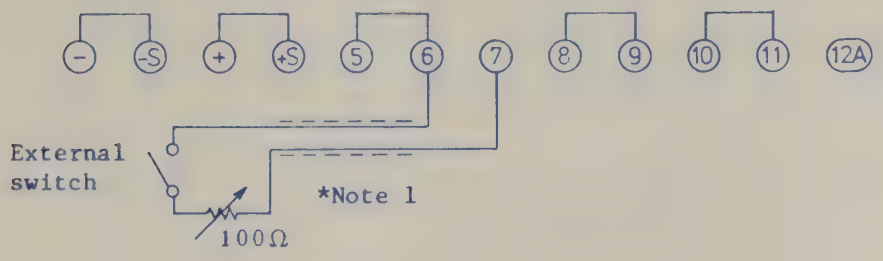


Figure 4-9

*Note 1: Use a 2-core shielded cable or a pair of stranded wires. Connect the shielded wire to the "+" output terminal.

Note: When the output is off, the voltage limit switch cannot be used although the current limit switch can be used.

4-4. Output Current Control with an External Voltage or Resistance

A. Control with an external resistance

1. Turn off the input power switch. (Be sure to turn off the power switch before connecting or disconnecting wires of the rear terminals.)
2. Disconnect the jumper from between terminals (10) and (11).
3. Connect a 10-ohm potentiometer and resistor R3 between terminals (11) and (12A).
4. Adjust the 10-ohm potentiometer so that the output current becomes zero when R3 is zero.

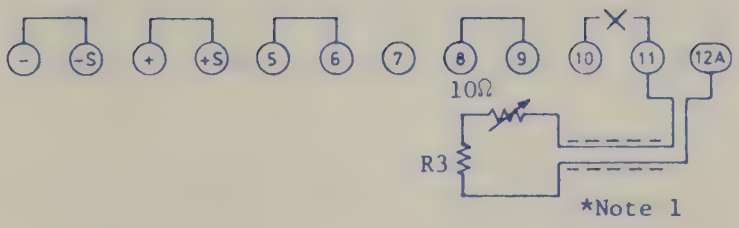


Figure 4-10

Output current Io = R3 × Imax [A]

where, R3 [kΩ] ≤ 1

Imax: Rated output current [A]

For fine adjustment of Io with respect to R3, use R2 shown in Figure 5-1.

*Note 1: Use a 2-core shielded cable or a pair of stranded wire. Connect the shield wire to the "+" output terminal.

Notes: Make sure that the output current does not exceed the maximum rated output current. (Io ≤ Imax)

Note that the current limit function will become utterly ineffective if the circuit between terminals (11) and (12A) is made open when the jumper is disconnected from between terminals (10) and (11).

B. Control with an external voltage

1. Turn off the power switch. Remove the cover of the main unit.

2. Throw switch SW1 on PCB A-141 board in the arrowhead direction as shown in Figure 5-1. Set and fix the cover.

3. Disconnect the jumper from between terminals (10) and (11).

4. Apply the external control voltage between terminals (11) and (12A), observing the polarity.

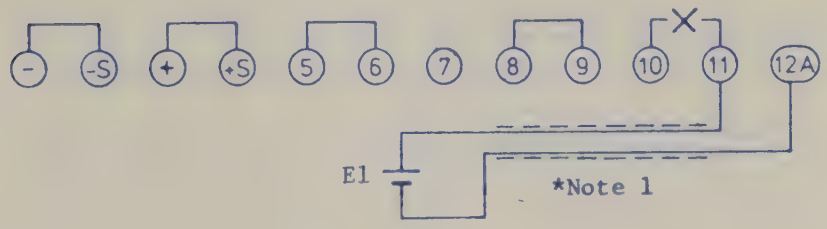


Figure 4-11

Output current $Io = \frac{E1}{Rs}$ [A]

where, E1: External control voltage [V]
Rs: Current detecting resistor [Ω]
(See the following table.)

Model	16-18L	35-10L	55-6L	70-5L	110-3L	160-2L	8-20L
Rs [Ω]	0.03	0.05	0.1	0.2	0.33	0.5	0.03

*Note: Use a 2-core shielded cable or a pair of stranded wires. Connect the shield wire to the "+" output terminal.

Notes: Make sure that the output current does not exceed the maximum rated output current. Note that, if an excessively large control signal is applied, an abnormally large current may flow and the instrument may be damaged.

4-5. One-control Parallel Operation

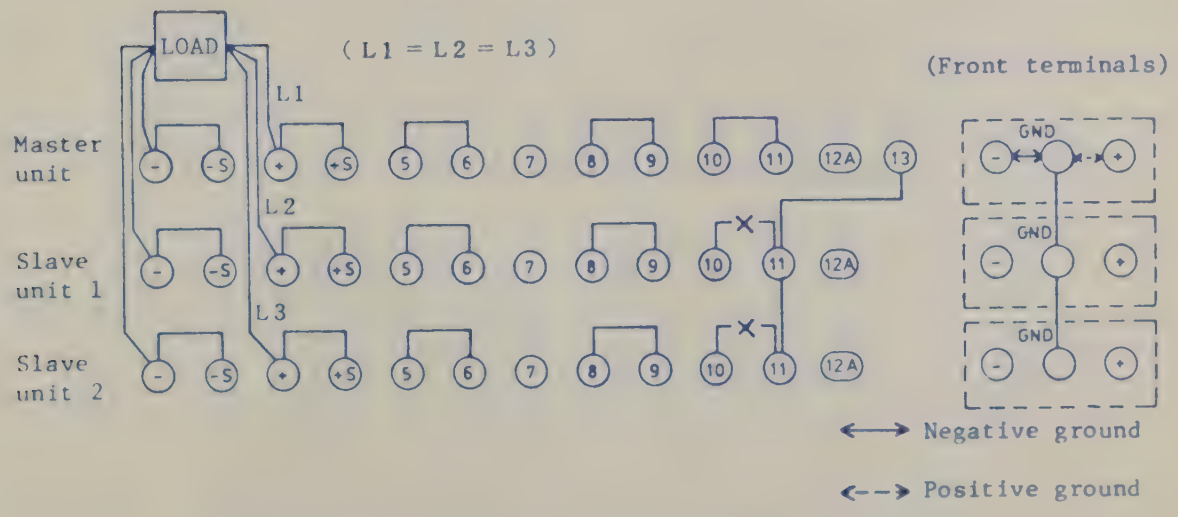
One master unit and any number of slave units can be operated in parallel to increase the current capacity, controlled by one unit (master unit) for operation.

1. Turn off the input power switches and remove the cover of the master unit.

2. Disconnect the jumper from between terminals (10) and (11) of each slave unit.

3. Connect terminal (13) of the master unit to terminal (11) of each slave unit through the electrical connection hole. Put on and fix the cover. (Terminal (13) is located on printed board A-227 by the side of input fuse.) (See Figures 4-13 and 5-1.)

4. Connect in parallel the output terminals of all instruments, for respective polarities. Use wires of the same length in order to maintain balance among the instruments.



Set the constant-voltage setting knobs of all slave units to the maximum position. Of the slave units, the red LED lamps constantly light to indicate the constant-current mode.

Figure 4-12

5. For grounding, use the GND terminal on the front panel. For one-control parallel operation, connect the GND terminals as shown in Figure 4-12.

6. For one-control parallel operation with remote sensing, disconnect the jumper wires from between (+S) and (+) terminals and between (-S) and (-) terminals, and make the required connections only for the master unit, as explained in 4-1 "Remote Sensing."

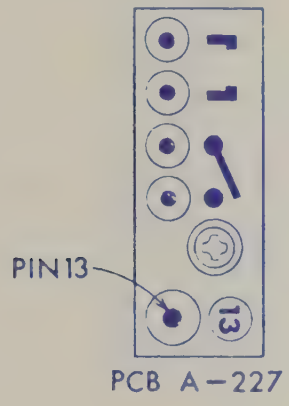


Figure 4-13

Note: Set the constant-voltage setting knobs of the slave units to the maximum position. For the wire gauges for the required currents, see the following table.

Nominal cross section area	Current rating recommended by Kikusui	Current rating specified by the Technical Ordinance for Electrical Installations (Article 29) JAPAN
5.5 mm^2	20 A	49 A
8 mm^2	30 A	61 A
14 mm^2	50 A	88 A
22 mm^2	80 A	115 A
38 mm^2	100 A	162 A
80 mm^2	200 A	257 A

Ta = 30°C

4-6. One-control Series Operation

One master unit and any slave units can be operated in series to obtain a higher output voltage.

1. Turn off the input power switch.
2. Disconnect the jumper from between terminals (8) and (9) of each slave unit.
3. Connect external resistor as shown in Figure 4-14.
4. Connect in series the rear output terminals as shown in Figure 4-14. (Use wires of sufficient current rating.)
5. Connect together the GND terminals of the units to the required potential line.
6. Set the current setting knobs of the slave units to the maximum position.
7. Set the voltage setting knobs of all slave units to the maximum position. (The output voltage can be controlled with these knobs.)

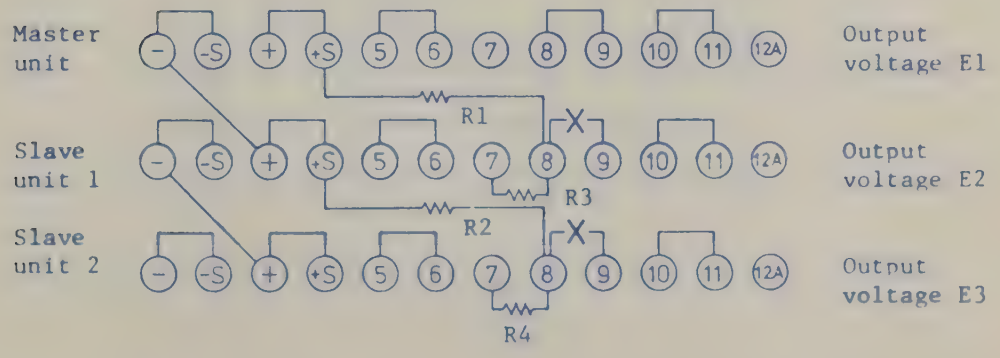


Figure 4-14

Calculation of external resistor R1 (R2)

$$R1 = \left(\frac{E1}{E2} \times A\right) - B$$

where, $R1 \geqq 0$ [kΩ]

$E2 \leqq \frac{A}{B} E1$ ..... (condition for E2)

E1: Output voltage [V] of master unit

E2: Output voltage [V] of slave unit 1 which depends on output voltage E1 of master unit

A, B: Constants of slave unit 1. (See the table below.)

R3, R4: 72 kΩ (Connect these resistors when 8-20L slave units are used.)

The value of R2 also can be calculated in a similar manner as above, substituting E1 with E2 and E2 with E3.

Model	16-18L	35-10L	55-6L	70-5L	110-3L	160-2L	8-20L *
A	16	35	55	70	110	160	8
B	9	9	9	9	9	9	8

Notes:

1. Make the total series output voltage not higher than the withstanding voltage to the ground of instruments involved.

2. Set the constant-current setting knobs of the slave units to the maximum position.

3. Pay attention to the wattage of the external resistors R1 (R2, R3, R4). Use resistors of 2-watt or over and of good temperature characteristics and less aging degradation.

4. For one-control series operation, units of different models can be connected if they are of the same type.

5. For the remote sensing operation, use the +S terminal of the highest voltage unit (master unit) and the -S terminal of the lowest voltage unit (slave unit).

4-7. Constant-current Discharge of Battery or Capacitor

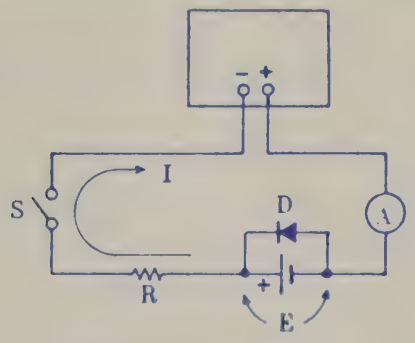


Figure 4-15

Resistance of R: $R = \frac{E\ [V]}{I\ [A]}$

Power consumption by R: $P = I^2R\ [W]$

where, E: Terminal voltage of battery or capacitor at the beginning of discharge

R: Discharge resistor

I: Discharge current (constant current)

D: Reverse current blocking diode

1. Set the output voltage of the power supply with the constant-voltage setting knob to a voltage higher by several volts than the terminal voltage of the battery or capacitor which is to be discharged. (By this setting, constant-current discharge can be done until the voltage of the battery or capacitor becomes zero.)

2. Calculate the resistance of the discharge load resistor (R). Pay attention to the wattage of the resistor.

3. Keeping depressed the current/voltage limit switch, set the discharge current with the constant-current setting knob.

4. Close switch S. Constant-current discharge operation will start.

Notes: 1. To stop the discharge operation, open switch S. (Even when the input power switch of the power supply is cut off, the discharge current flows through the diode which is connected in parallel with the output circuit of the power supply.)

2. Be sure to connect the discharge load resistor (R). (If the battery or capacitor is directly connected, the power supply may be damaged.)

3. Be sure to connect the reverse current blocking diode.

Charging of a battery or a capacitor can be done in a similar method as shown in Figure 4-15, the only differences being that the polarity must be inverted and R, D and S are not required. The charge-up voltage can be set with the voltage setting knob and the charge current with the current setting knob. The charging operation automatically stop when the battery is charged up.

RF: Reference voltage amplifier

CV: Constant-voltage amplifier

CC: Constant-current amplifier

D: Drive circuit

R_V: Voltage adjusting resistor

R_C: Current adjusting resistor

R_S: Current detecting resistor

R_F: Voltage detecting resistor

R_1: Voltage detecting resistor

Z_V: Zener diode for constant voltage

Z_C: Zener diode for constant current

D1: Protecting diode against reverse polarity connection

D2: Reverse current blocking diode (Not provided in PAD8-20L and 16-18L)

D3: Protecting diode

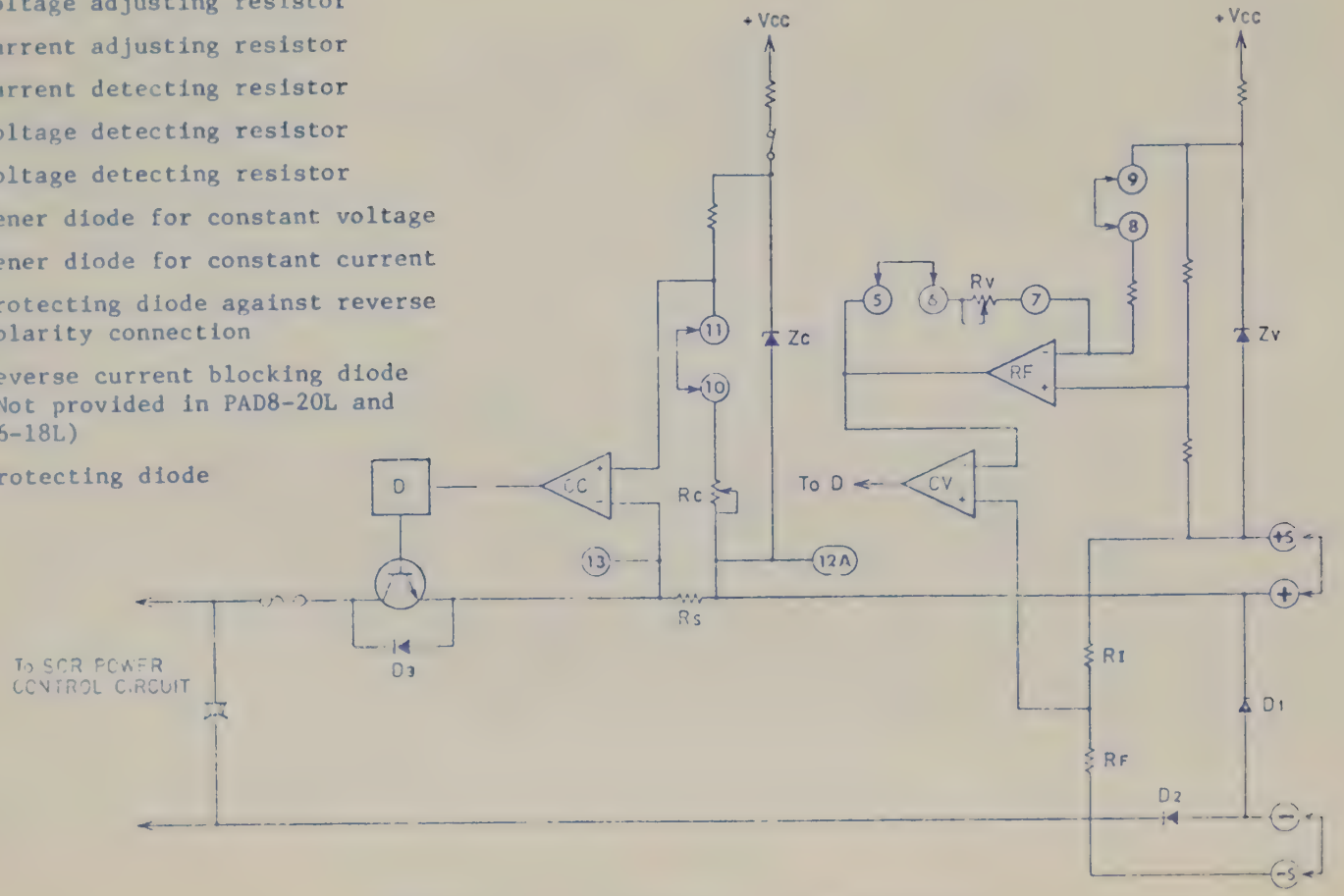


Figure 4-16. Connections of rear terminals

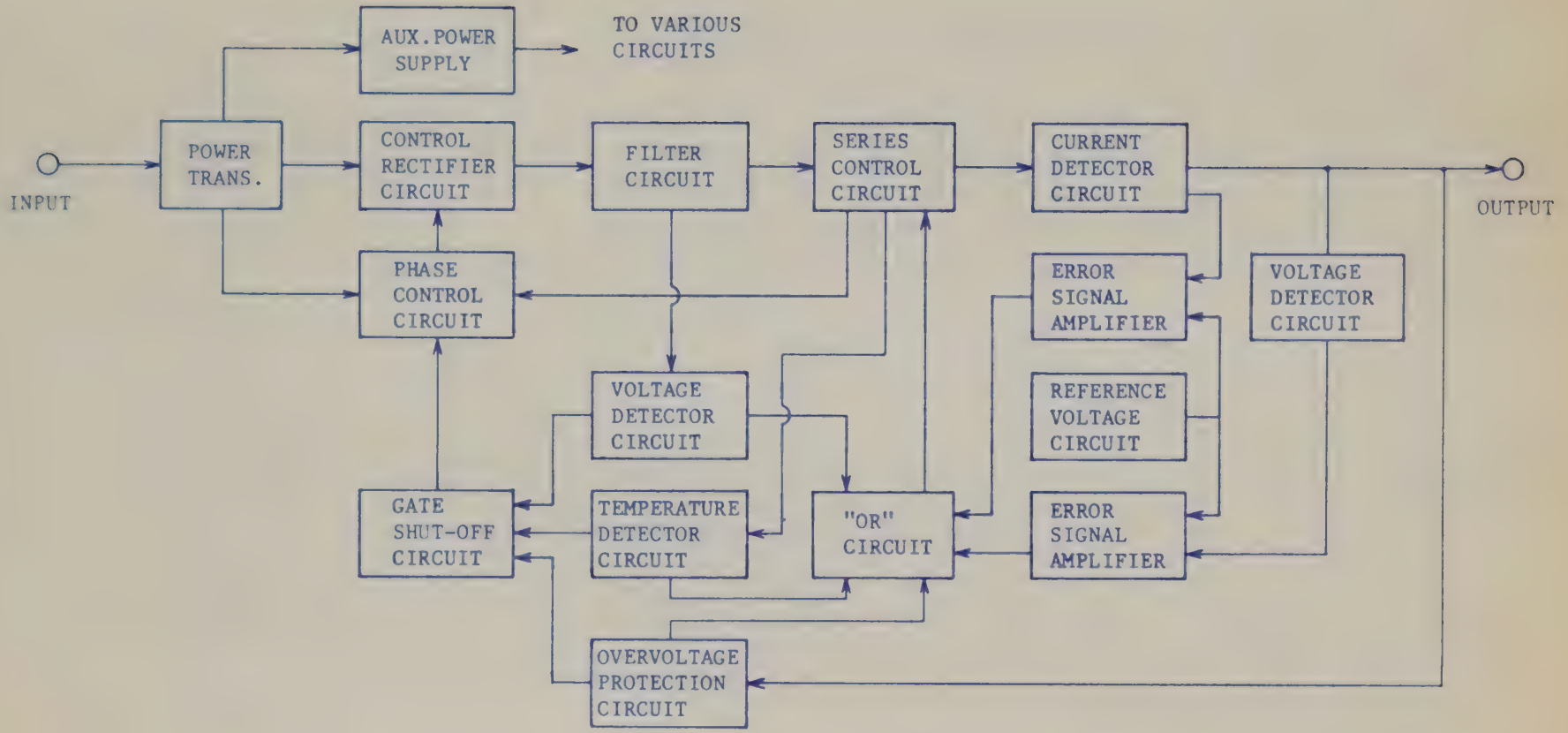


Figure 4-17. Block diagram

SECTION 5. MAINTENANCE

5-1. Inspection and Adjustment

Periodically inspect and adjust the power supply so that it maintains its initial performance for a long time.

5-1-1. Removing Dust and Dirt
5-1-2. Inspecting the Power Cord and Plug
5-1-3. Calibrating the Voltmeter
5-1-4. Calibrating the Ammeter
5-1-5. Calibrating the Current/Voltage Limit Switch
5-1-6. Adjusting the Maximum Variable Constant-voltage Range
5-1-7. Adjusting the Maximum Variable Constant-current Range

5-1-1. Removing Dust and Dirt

When the instrument panel has become dirty, lightly wipe it with a cloth moistened with diluted neutral soapsuds or alcohol and, then, wipe it with a dry cloth. Do not use benzine or thinner. Blow away dust collected inside the instrument and in the ventilation holes of the casing, using a compressed air or a vacuum cleaner.

5-1-2. Inspecting the Power Cord and Plug

Check for that the vinyl cover of the cord is not damaged. Check the plug for play, loose screws and damage.

5-1-3. Calibrating the Voltmeter

Connect an external voltmeter of an accuracy of 0.5% or better to the output terminals, set the output voltage at the value indicated on Table 5-1, and calibrate the instrument voltmeter with R6 (V) at the right-hand section on the front panel. (See Figure 5-1.)

5-1-4. Calibrating the Ammeter

Connect an external ammeter of an accuracy of 0.5% or better in the output circuit, set the output current at the value indicated on Table 5-1, and calibrate the instrument ammeter with R5 (A) at the right-hand section on the front panel. (See Figure 5-1.)

5-1-5. Calibrating the Current/Voltage Limit Switch

o Calibration of limit voltage

Set the output voltage at the value indicating on Table 5-1. Press the current/voltage limit switch and so adjust R3 on PCB A-141 that the voltmeter reads the set voltage value. (See Figure 5-1.)

o Calibration of limit current

Set the output current at the value indicated on Table 5-1. Press the current/voltage limit switch and so adjust R1 on PCB A-141 that the ammeter indicates the set current value.

5-1-6. Adjustment of Maximum Variable Constant-voltage Range

Connect to the output terminals an external voltmeter of an accuracy of 0.5% or better, set the constant-voltage setting knob in the maximum position (extremely clockwise position), and so adjust R4 on PCB A-141 that the instrument voltmeter reads the value indicated on Table 5-1. (See Figure 5-1.)

5-1-7. Adjustment of Maximum Variable Constant-current Range

Connect in the output circuit an external ammeter of an accuracy of 0.5% or better, set the constant-current setting knob in the maximum position (extremely clockwise position), and so adjust R2 on PCB A-141 that the instrument ammeter reads the value indicated on Table 5-1. (See Figure 5-1.)

Table 5-1

Model		PAD 16-18L	PAD 35-10L	PAD 55-6L	PAD 70-5L	PAD 110-3L	PAD 160-2L	PAD 8-20L
Voltmeter adj	R6	16.0 V	35.0 V	55.0 V	70.0 V	110 V	160 V	8.0 V
Ammeter adj	R5	18.0 A	10.0 A	6.0 A	5.0 A	3.0 A	2.0 A	20.0 A
Voltage limit adj	R3	16 V	35 V	55 V	70 V	110 V	160 V	8 V
Current limit adj	R1	18 A	10 A	6 A	5 A	3 A	2 A	20 A
Maximum voltage adj	R4	16.6 V	36 V	56 V	72 V	115 V	165 V	8.5 V
Maximum current adj	R2	18.5 A	10.5 A	6.2 A	5.1 A	3.1 A	2.1 A	21 A

R1: Current limit adjusting potentiometer

R2: Maximum current adjusting potentiometer

R3: Voltage limit adjusting potentiometer

R4: Maximum voltage adjusting potentiometer

R5: Ammeter adjusting potentiometer

R6: Voltmeter adjusting potentiometer

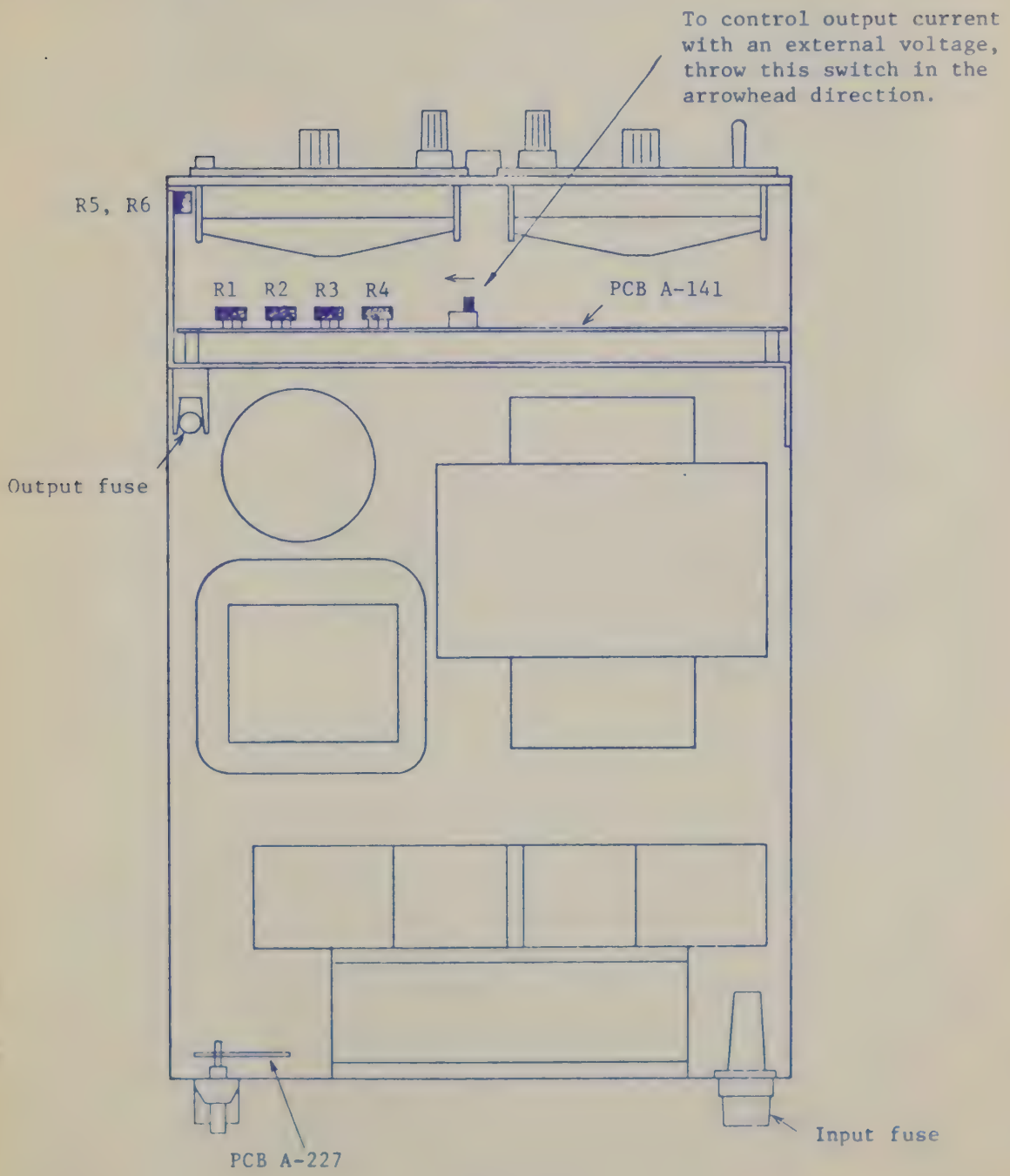

To control output current with an external voltage, throw this switch in the arrowhead direction.
R5, R6
R1 R2 R3 R4
PCB A-141
Output fuse
PCB A-227
Input fuse

Figure 5-1

5-2. Troubleshooting

The most probable causes of troubles are shown in the following table. When a failure of the power supply is found, contact Kikusui agent in your area.

Symptom	Check item	Probable cause
No output (No output is produced at all or only a slight output is produced.)	1. Has the overvoltage protector tripped?	o Set voltage too low
	2. Shorting bar disconnected?	o Disconnected or loose shorting-bar
	3. Is fan stalled?	o Trip of overheat protector (Replace fan.)
	4. Does voltage drop slowly when light load is connected?	o Trip of protective circuit due to failure of rectifier circuit
	5. Is the input power fuse blown?	o Input line voltage too high (Replace fuse.) o Failure of rectifier circuit
	6. Is lamp lighted?	If not lighted, o Open-circuiting of power cord
	7. Are the lamps alternately lighting, indicating rapid transitions of operating domains?	o Too narrow constant-voltage and constant-current setting ranges

Symptom	Check item	Probable cause
	8. Are the shorting-bars correctly connected?	o Wrong connection of shorting-bar(s)
	9. Is the output power fuse blown?	o Output current exceeding the rated value o Power transistor failure
	10. Is the circuit oscillating?	o Phase inversion caused by remote sensing circuit (Connect an electrolytic capacitor at the load end.) (See Figure 4-1.) o Re-adjustment
	11. Is a current flowing despite no load?	If flowing, o Failure of the protective diode connected in parallel with the output (This diode may be damaged if such load as battery is connected in the reverse polarity.)
	12. Other than the above	o Circuit failure
OVP circuit trips.	1. Is the shorting-bar disconnected? (Between (5) and (6).)	o Disconnected or loose shorting-bar
	2. Can output voltage (current) be reduced?	o Power transistor failure o Bleeder circuit failure

Symptom	Check item	Probable cause
Unstable output	1. Is the shorting-bar(s) loose?	o Incorrect connection of shorting-bar(s)
	2. Is the AC line voltage correct?	o AC line voltage not within the specified range
	3. Special type of load	o See 2-3 (Loads).
	4. When matter of drift is critical	o Allow more than 30 minutes of stabilization time.
	5. Other than the above	o Circuit failure
Large ripple voltage	1. Is the AC line voltage correct?	o Input voltage too low
	2. Are the output terminal or ground terminal floated?	o 50/60 Hz induction (If possible, ground the terminal with a capacitor of 1 μF or over.)
	3. Is strong source of magnetic or electric field present near the power supply? (Is there nearby auto-transformer, power transformer, or an oscillating source?) (Especially when in the constant-current mode)	o Electromagnetic induction (Move the source of trouble. Strand the wires.)
	4. Other than the above	o Circuit failure o (Re-adjust)

WARRANTY

All instruments manufactured by KIKUSUI ELECTRONICS CORP. are warranted against defects in materials and workmanship for a period of two years from the date of original shipment from the factory. However, this warranty excludes batteries, lead wires and probes, and CRT's are warranted only for a period of one year from the date of original shipment from the factory.

In the event of any defects in materials or workmanship, KIKUSUI ELECTRONICS CORP. will, at its sole option, repair or replace the defective instrument covered by this warranty without charge. To obtain warranty service, the defective instrument must be returned within thirty (30) days of the expiration of the applicable warranty period to KIKUSUI INTERNATIONAL CORP. properly packaged and with transportation and insurance prepaid. We will reship at our expense only to destinations in the United States.

Any defect in materials or workmanship determined by KIKUSUI INTERNATIONAL CORP. to be attributable to customer alteration, modification, negligence or misuse is not covered by this warranty.

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